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REPORT NO. RD-64-90

FINAL REPORT

Project No. 108-030-01V

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EVALUATION OF GENERAL AVIATION TRANSPONDERS

JUNE 1964

This report has been approved for general distribution.

FEDERAL AVIATION AGENCY
Systems Research & Development Service
EVALUATION DIVISION
Atlantic City, New Jersey

FINAL REPORT

EVALUATION OF GENERAL AVIATION TRANSPONDERS

PROJECT NO. 108-030-01V
REPORT NO. RD-64-90

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This report is approved for submission to the Director, Systems Research and Development Service. The conclusions and recommendations are those of the Evaluation Division. This report does not necessarily reflect FAA policy in all respects and it does not in itself, constitute a standard, specification, or regulation.

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June 1964

FEDERAL AVIATION AGENCY
Systems Research and Development Service
Evaluation Division
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Federal Aviation Agency, Atlantic City, N. J.
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ABSTRACT

Operational performance tests were conducted with General Aviation Transponders (GAT), developed by the Wilcox Electric Company, Inc., and the Hazeltine Technical Development Center, Inc., under Federal Aviation Agency contracts. Four each of the prototype transponders were furnished and installed by FAA for operation in various aircraft.

Questionnaires completed by the pilots of these aircraft provided data for estimating the performance and utility of the GAT along with benefits which might be derived from widespread implementation.

It was concluded that while both types of General Aviation Transponders (Wilcox and Hazeltine) met the contract specifications, design changes are required to correct performance deterioration during operational use. It was also concluded that acceptance and utilization of the GAT by the General Aviation Community depend upon the extent to which its purchase price can be reduced and the equipment operational life increased.

It was recommended that the FAA continue to foster introduction of transponders to general aviation by familiarizing the General Aviation Community with the ATCRBS, by investigation of design changes which will improve the GAT.

INTRODUCTION

Purpose

The purpose of this project was to conduct a technical and operationa evaluation of General Aviation Transponders to (1) determine extent of compliance with procurement specifications and with the performance criteria associated with the Air Traffic Control Radar Beacon System (ATCRBS) and (2) assess the performance and utility under actual operational conditions,and the benefits which might be derived from widespread implementation.

Background

In 1960, the Federal Aviation Agency (FAA) undertook the development of General Aviation Transponders (GAT) in order to make available to owners of general aviation aircraft a broader access to the Air Traffic Control Radar Beacon System (ATCRBS). Prior to the development of GAT, the weight, power consumption, and cost of the existing types of airborne transponder had been too high for the majority of general aviation aircraft owners.

The Systems Research and Development Service (SRDS) of the FAA sponsored the development of two models of the GAT equipment. One model was developed under Contract FAA/BRD-234 by Wilcox Electric Company, Inc., and the other by Hazeltine Technical Development Center, Inc., under Contract FAA/BRD-233. The contractors were required to furnish five production prototype transponders.

The Wilcox and Hazeltine GATs were designed to reply to Mode 3 interrogations by the ATCRBS with any one of 64 codes and a special "ident" pulse selectable by the pilot. Both equipments conformed to the three-pulse side-lobe-suppression system. Semi-conductors were employed throughout except that the Wilcox transponder incorporated a transmitter output tube, and the Hazeltine transponder contained both a local oscillator tube and a transmitter output tube. Each transponder was packaged in a 3.5" x 7.6" x 12.5" case. Their characteristics are summarized in Table I.

TABLE I

SUMMARY OF CHARACTERISTICS*

	Wilcox GAT	Hazeltine GAT
Power Requirements	13.75 vdc, 4.0 amps (max) or 27.50 vdc, 2.0 amps (max)	13.5 vdc, 4.0 amps (max) or 27.5 vdc, 2.0 amps (max)
Receiver Frequency	1030 mc ± 2.5 mc	1030 mc (nominal)
Receiver Bandwidth	3 db down, 3 mc 40 db down, 14 mc 60 db down, 25 mc	3 db down, 8 mc 40 db down, 28 mc 60 db down, 50 mc
Receiver Image and Spurious Responses	at least 35 db down from normal receiver trigger level	at least 60 db down from normal receiver trigger level
Receiver Sensitivity	-74 dbm (min) for 50% replies	-74 dbm for 50% replies (Low Sensitivity -62 dbm)
Transmitter Frequency	1090 mc ± 3.0 mc	1090 mc ± 3.0 mc
Transmitter Power Output	500 watts, peak pulse power	300 watts, peak pulse power
Weight (Total)	11.3 lbs.	10.4 lbs.

*Complete electrical descriptions of the Wilcox and Hazeltine GAT can be found in the FAA Interim Report entitled, "Evaluation of General Aviation Transponders", dated November 1962

The evaluation was divided into three phases of testing. Phase I consisted primarily of Contractual Acceptance Tests which were carried out at NAFEC. Phase II consisted of flight tests under controlled conditions during which the anticipated performance of the transponders was confirmed. The FAA Interim Report (Project 108-8V), titled "Evaluation of General Aviation Transponders," dated November 1962, presented the results of the Phase I and II tests. This Interim Report also contains a description of the equipments and the aircraft installations.

The acceptance tests consisted of bench tests on the ten transponders (five Wilcox and five Hazeltine) to determine contractor compliance with contract design specifications.

Flight tests were conducted to determine maximum operational range of these GAT equipments at several flight altitudes (up to 15,500 feet), compatibility of the equipments with the Air Traffic Control Radar Beacon System (ATCRBS), and appearance of their return signal on Plan Position Indicator (PPI) displays.

Results of the tests indicated that all equipments performed in accordance with the contract specifications. In addition, both the Wilcox and Hazeltine transponders satisfactorily performed to a maximum range closely approximating radio line-of-sight and were compatible with the ATCRBS.

The User Test phase (Phase III), reported herein, was designed to obtain reliability, maintainability, utility, and general operational performance data over a prolonged period of operation under conditions typical of general aviation. Plans for these tests under Phase III were formulated around the concept of operating a number of the transponders in representative types of general aviation aircraft. The User Tests were undertaken when eight aircraft had been volunteered. A transponder was installed in each of these and initially flight checked at NAFEC during October and November 1962. Subsequently, another owner volunteered to participate with an aircraft carrying a transponder loaned directly by the Hazeltine Technical Development Center, Inc.

During the Phase III tests, eighty-two (82) pilots participated on one or more flights in GAT-equipped aircraft.

DISCUSSION

Phase III Test Program

User Tests: Users were selected from the general aviation community as being typical of those private and corporate owners who could be expected to purchase, install, and make use of a suitable GAT if they found the services of the ATCRBS sufficiently beneficial. These owners volunteered to permit the Government to install and test one transponder in their aircraft in return for which they agreed to prepare and return completed questionnaires regularly throughout a six-month test period. An additional volunteer operated an aircraft in which a Hazeltine GAT had been installed privately. In addition to the participation of general aviation pilots and aircraft, the GAT was also installed and operated in two military and one FAA aircraft during the test period. There were nine GAT-equipped aircraft participating in this test phase (Appendix I). These GAT-equipped aircraft were piloted by 82 pilots, 67 of which were from the military.

While the equipment was being installed at NAFEC, the pilots were briefed regarding the operation of the GAT with the ATCRBS. During the briefing, the pilots were also given instructions for completing and submitting questionnaires. Other pilots who entered the program later were provided with comparable information. Once the installation had been completed, each aircraft was flight checked to confirm the proper operation of its GAT and to familiarize the pilot with the operating controls.

The entire user evaluation was based upon the experience of various pilots who were left free to use the GAT or not as they wished. They were obliged only to complete the questionnaire (samples shown in Appendixes II and III) as well as they were able, and to return the equipment to NAFEC at the end of the test period, or sooner if it failed to operate normally.

Flight test data were collected during the period from February 1963 through August 1963. One questionnaire (Appendix II) was completed each time the GAT was operated. It contained factual data as well as subjective comments. A second type of questionnaire (Appendix III) was completed at bimonthly intervals. It contained a summary of general impressions and appraisals by the pilot regarding the transponder performance and ATC service experienced during this period. In addition, technical information was accumulated as equipment failures occurred and correlation with the questionnaires was accomplished.

Installation Program: Before the eight Government-owned GAT equipments were installed for the User Tests, the units were calibrated, tested, and found to satisfy the stated requirements of the specifications. The assortment of aircraft types included high-wing and low-wing configurations, some with single engines, and others with two. Most were of the same general size but the Gulfstream and VC-47A were substantially larger. Every effort was made to reduce the shadowing effects of empennage or structure upon the radiation pattern of the transponder antenna. Variations occurred in the placement of GAT components and controls. Details of the installations are given below.

Wilcox GATs - The Wilcox GATs were installed in four aircraft for the User Test program as follows:

GAT Serial No.	Aircraft Type
070	Douglas VC47A (military)
071	Cessna 180
072	Grumman Gulfstream (FAA)
074	Beech Twin Bonanza

The GATs installed in the Douglas and Gulfstream aircraft were mounted in the radio equipment racks or cabinets and the GAT Control Head was mounted on the control panel of the cockpit. (See FIGS. 1 and 2) The GATs for the Cessna and Bonanza aircraft were installed in baggage and nose compartments, respectively. The GAT Control Heads were mounted on the instrument panels of these aircraft (see FIGS. 3 and 4).

Wilcox Transponder Serial #071 was modified for operation from a 13.75 volt dc source; all others received their primary power from a 27.5 volt dc source.

All GAT antennas were installed in an optimum location along the center line on the underside of the aircraft. Locations of the Wilcox GAT Antenna are shown in Figures 1 through 4.

Hazeltine GATs - The four Hazeltine GATs were installed in the following aircraft for the User Test program:

GAT Serial No.	Aircraft Type
2	Twin Cessna U3A (military)
3	Cessna 172
4	Beech Bonanza BN-35
5	Beech Bonanza K-35

FIG. 1A - GAT CONTROL HEAD INSTALLED IN RIGHT SIDE OVERHEAD OF COCKPIT RADIO PANEL AREA

FIG. 1B - GAT INSTALLED IN BOTTOM OF RADIO RACK, RIGHT SIDE, FORWARD

FIG. 1 WILCOX GENERAL AVIATION TRANSPONDER INSTALLED IN DOUGLAS VC-47A AIRCRAFT

FIG. 2A - GAT CONTROL HEAD INSTALLED IN PANEL AT LEFT SIDE OF PILOT SEAT

FIG. 2B - GAT INSTALLED IN SUPPLEMENTARY CABINET AT REAR OF RADIO RACK, AIRCRAFT RIGHT SIDE, FORWARD

FIG. 2 WILCOX GENERAL AVIATION TRANSPONDER INSTALLED IN GRUMMAN GULFSTREAM AIRCRAFT

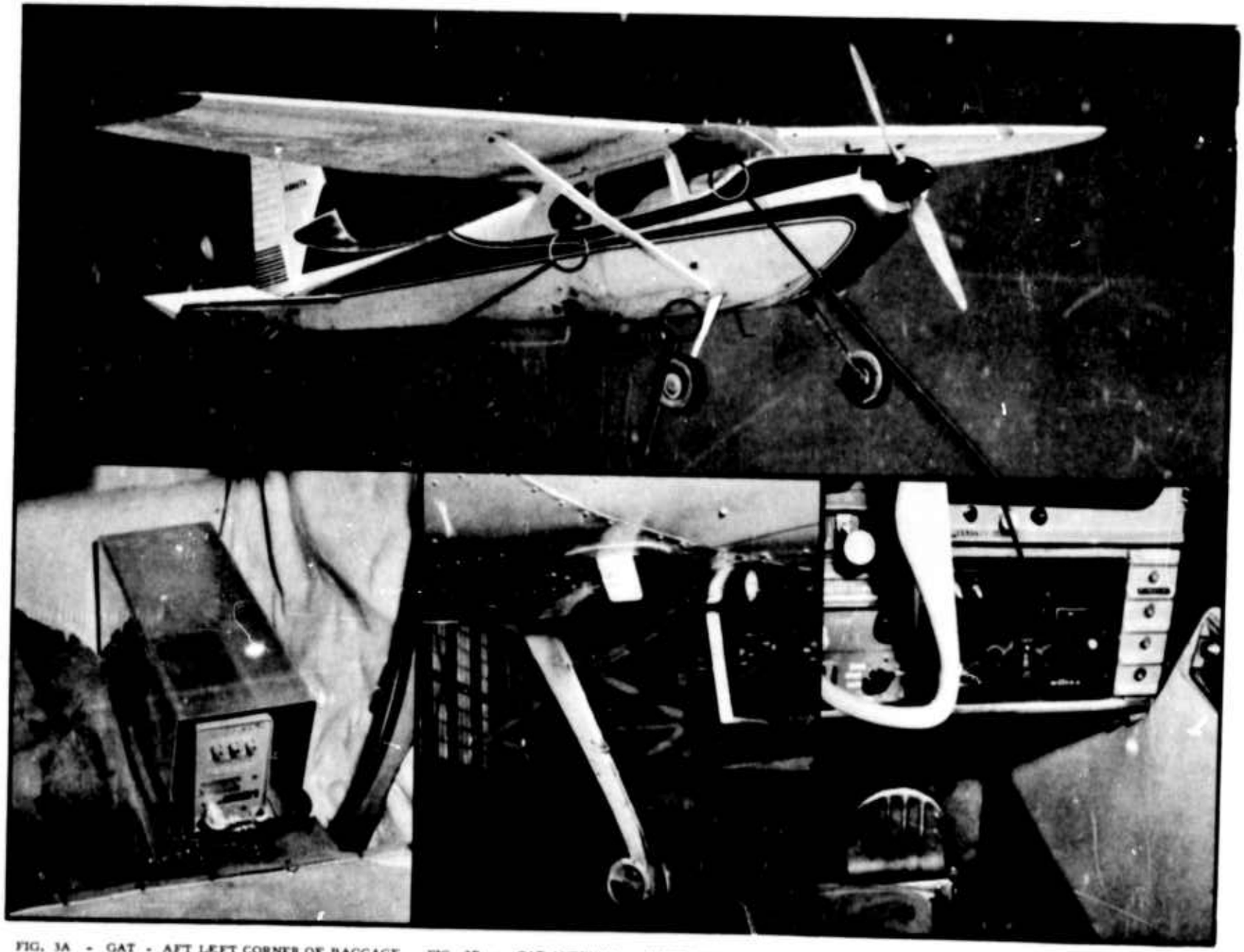

FIG. 3A - GAT - AFT LEFT CORNER OF BAGGAGE COMPARTMENT

FIG. 3B - GAT ANTENNA - UNDER COCKPIT AREA, AIRCRAFT CENTERLINE

FIG. 3C - GAT CONTROL HEAD - LOWER RIGHT SIDE OF INSTRUMENT PANEL

FIG. 3 WILCOX GENERAL AVIATION TRANSPONDER INSTALLED IN CESSNA 180 AIRCRAFT

FIG. 4A - GAT - IN NOSE COMPARTMENT

FIG. 4B - GAT ANTENNA - UNDERSIDE CENTERLINE OF AIRCRAFT

FIG. 4C - GAT CONTROL HEAD - ABOVE CENTRAL SECTION OF INSTRUMENT PANEL

FIG. 4 WILCOX GENERAL AVIATION TRANSPONDER INSTALLED IN TWIN BONANZA AIRCRAFT

Installations in three of the four aircraft (Twin Cessna U3A, Cessna 172, and Beech Bonanza K-35) resulted in the GAT being located in the fuselage section aft of the baggage compartment as shown in Figures 5, 6, and 7. In the other aircraft (Beech Bonanza BN-35), the GAT was installed as shown in Figure 8 in the forward section of the baggage compartment.

The GAT Control Head was installed in three of the four aircraft on a small subpanel fastened to the underside of the aircraft instrument panel. In the case of the Twin Cessna, the GAT Control Head was installed in the glove compartment of the instrument panel (see FIG. 5A).

All GAT Antennas were installed in an optimum location along the centerline on the underside of the aircraft. Locations of the Hazeltine GAT Antennas are shown in the photographs of Figures 5 through 8.

Three aircraft equipped with the Hazeltine GAT employed NARCO DME equipment. It was necessary to install a special suppression modification circuit, recommended by NARCO (see Appendix IV), and to interconnect the GAT-DME by appropriate cabling so as to prevent mutual interference between the equipments.

Three Hazeltine GATs (Serial Nos. 3, 4, and 5) were modified at NAFEC for operation from a 13.5 volt dc source in the Cessna and two Beech Bonanza aircraft. The Hazeltine GAT (Serial No. 2) installed in Twin Cessna U3A aircraft was operated from a 27.5 volt dc source. Modifications were performed according to the manufacturer's instructions.

Data Collection: The data collected during User Test of the evaluation encompassed three distinct and interrelated categories: (a) equipment utilization by the test participants; (b) subjective opinion and comments of the users on the equipment; and (c) records of the equipment stability, maintenance requirements, and the nature of malfunctions. To facilitate the collection of data from the test participants, two (2) questionnaire forms, the Pilot's Questionnaire and the Pilot's Summary Questionnaire, were developed and furnished for completion by pilots at specified intervals throughout the program.

After each flight of a participating aircraft, the Pilot's Questionnaire (Appendix II) was completed. This questionnaire provided records of operational use (hours), operational performance (ATC reports), and subjective comments by the GAT user.

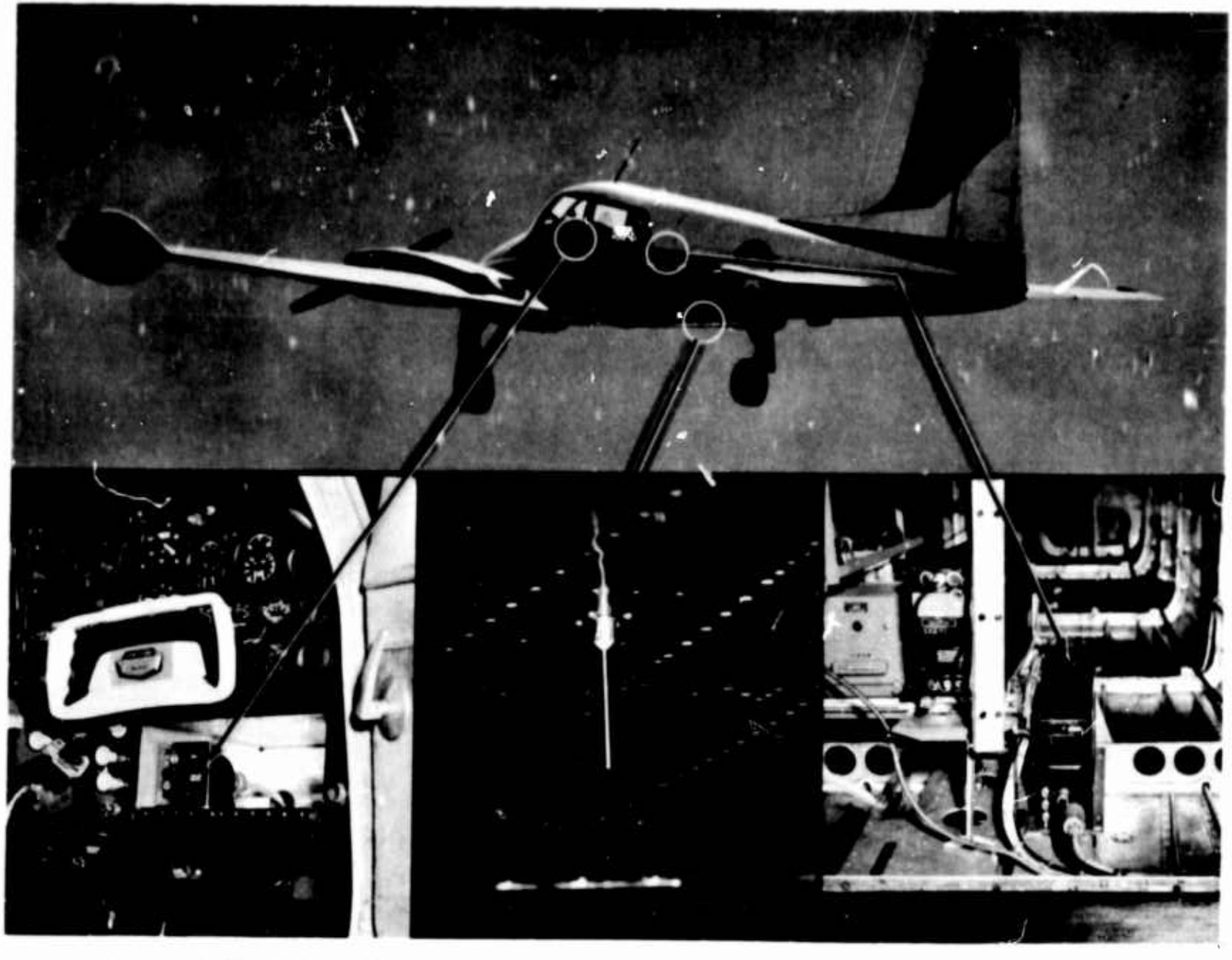

FIG. 5A - GAT CONTROL HEAD INSTALLED IN GLOVE COMPARTMENT

FIG. 5B - GAT ANTENNA - INSTALLED ON INSPECTION PLATE UNDER COCKPIT AREA, AIRCRAFT CENTERLINE

FIG. 5C - GAT INSTALLED IN FUSELAGE SECTION AFT OF BAGGAGE COMPARTMENT, LEFT SIDE

FIG. 5 HAZELTINE GENERAL AVIATION TRANSPONDER INSTALLED IN U3A TWIN CESSNA AIRCRAFT

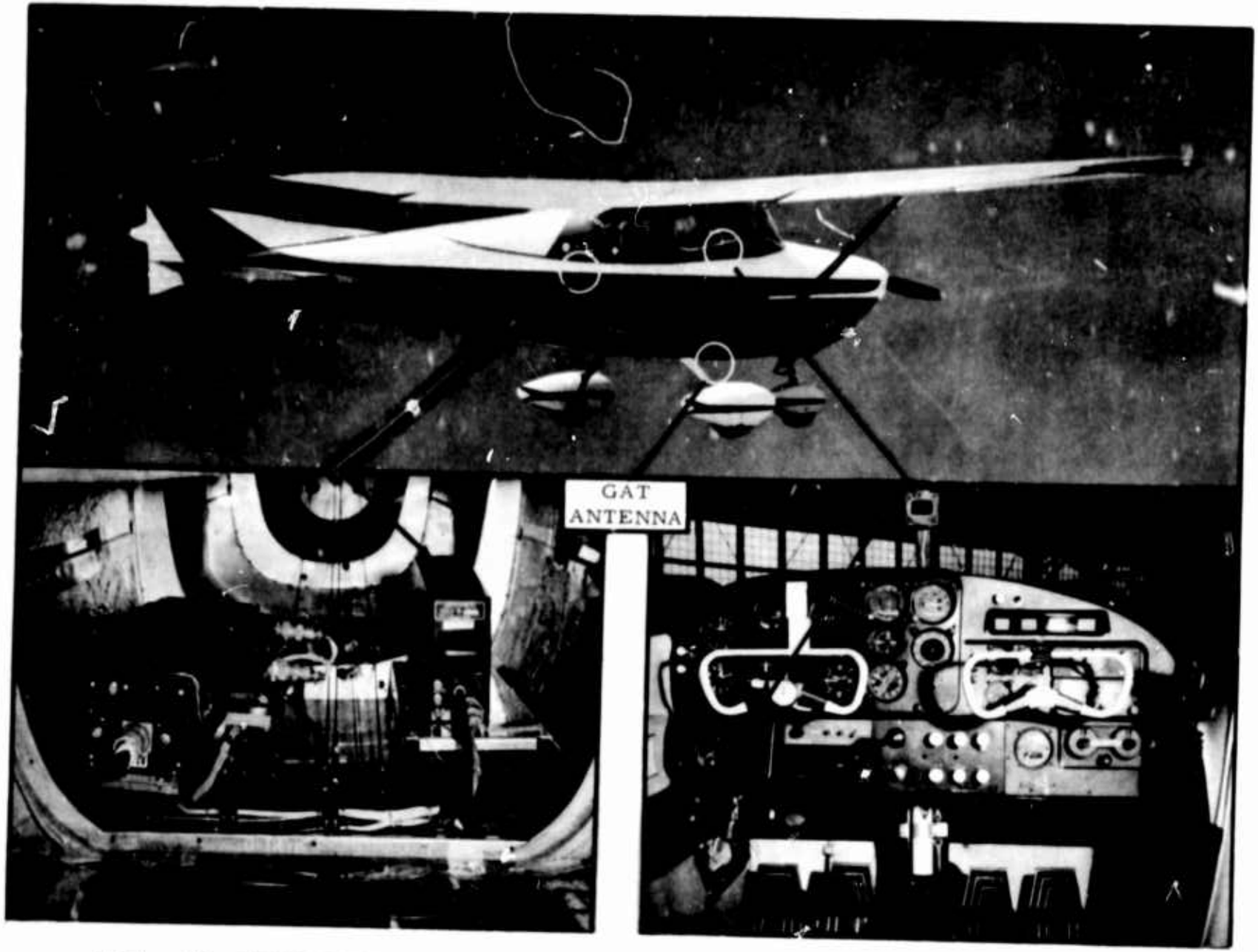

FIG. 6A - GAT - IN FUSELAGE SECTION, LEFT SIDE AFT OF BAGGAGE COMPARTMENT

FIG. 6B - GAT CONTROL HEAD - IN SUBPANEL UNDERSIDE LEFT OF INSTRUMENT PANEL

FIG. 6 HAZELTINE GENERAL AVIATION TRANSPONDER INSTALLED IN CESSNA 172 AIRCRAFT

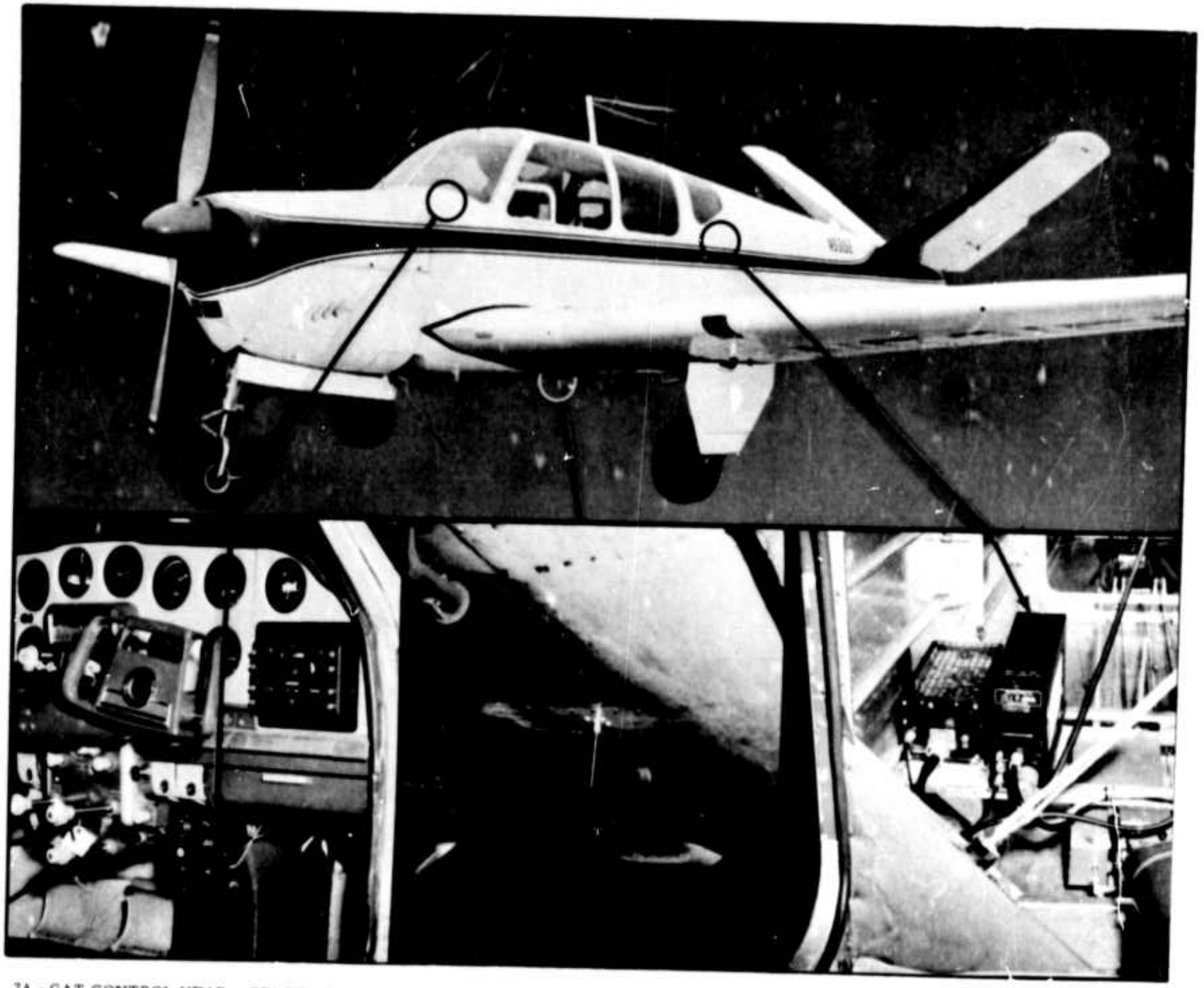

FIG. 7A - GAT CONTROL HEAD - BELOW LEFT OF GLOVE COMPARTMENT

FIG. 7B - GAT ANTENNA - UNDER FLOOR BOARDS ORWARD OF FRONT SEATS, AIRCRAFT CENTERLINE

FIG. 7C - GAT - AFT OF BAGGAGE COMPARTMENT, RIGHT SIDE OF FUSELAGE SECTION

FIG. 7 HAZELTINE GENERAL AVIATION TRANSPONDER INSTALLED IN K-35 BEECH BONANZA AIRCRAFT

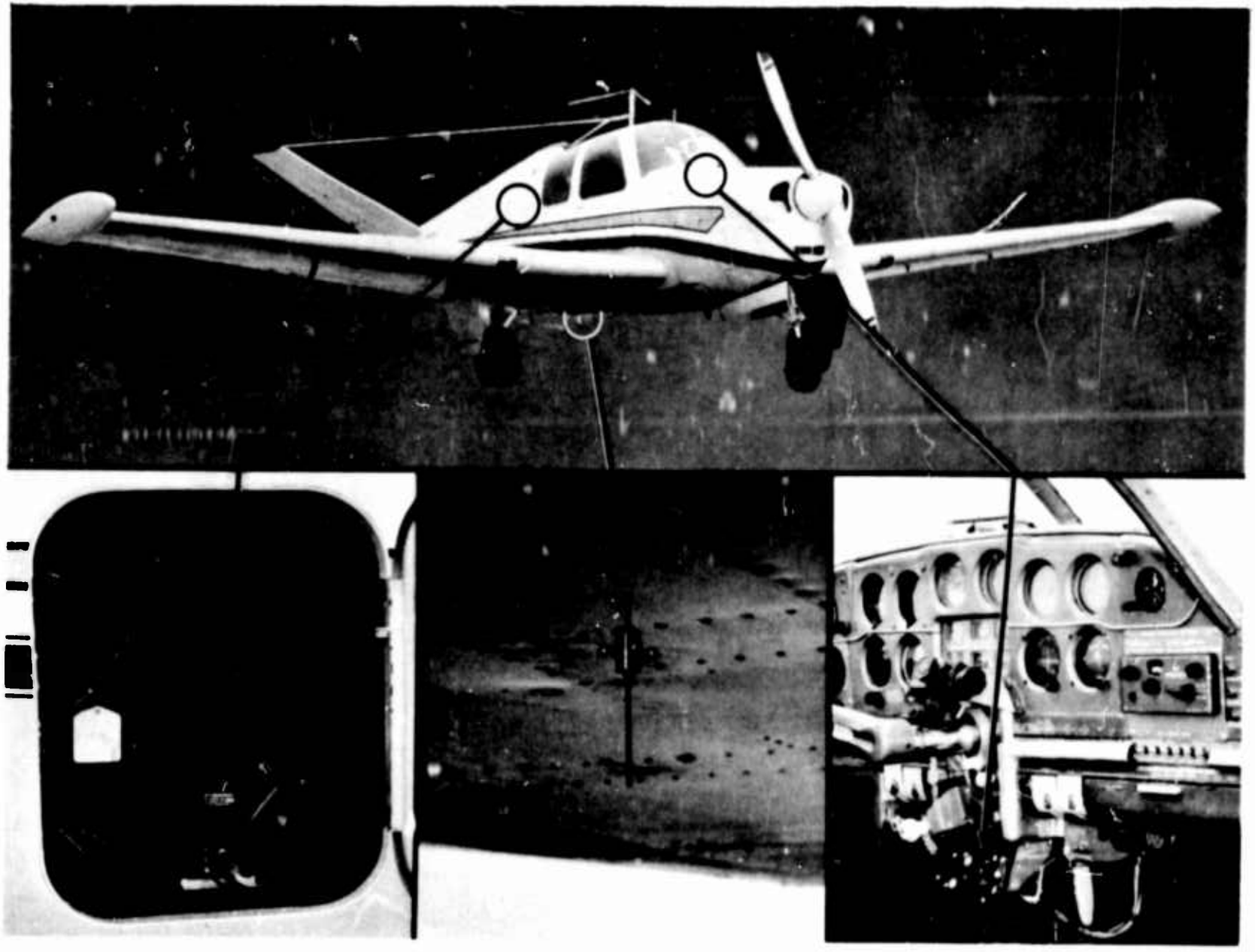

FIG. 8A - GAT - IN FORWARD SECTION OF BAGGAGE COMPARTMENT

FIG. 8B - GAT ANTENNA - FOUR FEET TO REAR OF NOSE WHEEL DOORS, AIRCRAFT CENTERLINE

FIG. 8C - GAT CONTROL HEAD - UNDERSIDE OF THROTTLE HOUSING

FIG. 8 HAZELTINE GENERAL AVIATION TRANSPONDER INSTALLED IN BN-35 BEECH BONANZA AIRCRAFT

The Pilot's Summary Questionnaire (Appendix III) was completed at the close of each two-month period throughout the test program. The primary information collected by means of these questionnaires consisted of subjective responses of the user relative to the operation of GAT with the ATCRBS. Participants were encouraged to express their personal reactions, comments, conclusions, and recommendations.

Data were obtained from the questionnaires and from direct contact with the users regarding performance, long-term operational stability, failures and maintenance requirements for all but one of the GAT equipments. The NAFEC records of the equipment maintenance and bench checks conducted at the NAFEC Beacon Test Facility during and following the User Tests, form the reference with which these results are compared.

Data Analysis: Analysis of the data collected throughout the six-month User Test program resulted in three types of information: (a) quantitative information derived from the Pilot's Questionnaires, giving the number of flights, hours of GAT use, and operational performance; (b) a summation of the subjective responses contained in the Pilot's Summary Questionnaire; and (c) a summation of the operational maintenance history of each of the FAA-owned GATs utilized in the test program. Deviations in the performance of the equipment are based upon results of comprehensive bench tests before and after the Phase III test activity.

Analysis of Pilot's Questionnaires - Two hundred eighty-four (284) Pilot's Questionnaires were submitted by the pilots who operated the nine GAT-equipped aircraft.

A. Geographic Areas over which GAT was Used - Examination of the Pilot Questionnaires submitted by the test participants showed that the aircraft operations were distributed in four areas of the continental United States as follows:

East Coast -	Massachusetts, New York, New Jersey, Washington, D. C., Pennsylvania	51%
Midwest -	Ohio, Indiana, Illinois, Missouri, Minnesota, Michigan	20%

South - Tennessee, Kentucky, Georgia, Florida, Alabama, Louisiana 14%

West - Arizona, Colorado, New Mexico, California, Washington 15%

It should be noted that no specific efforts were made to obtain a selected geographical distribution of the GAT-users' operating bases. Of the nine participating aircraft, seven aircraft were based on the East Coast, one in the Midwest, and one on the West Coast.

B. GAT Utilization - Aircraft operations reflected in these questionnaires totalled 737 hours during which the equipments were operated for a total of 597 hours (81 percent utilization).

VFR/IFR Standby - Segregation of the reported GAT operating hours into the categories of VFR-IFR-Standby reveals the following:

VFR Flight Conditions	223 hours
IFR Flight Conditions	291 hours
GAT on Standby	83 hours

A summation of the GAT utilization, including hours and percentage use of the "Normal-Low-Standby-Off" control switch functions, is presented in Tables II, III, and IV. The final entry of Table II shows that when the Military aircraft participation (51 percent of all operating hours) is withdrawn from the data, the utilization of the GATs does change from predominently IFR conditions to approximately equal IFR/VFR conditions.

A detailed reduction of the operating hours and percentages of GAT-use for each participating aircraft is presented in Appendixes V and VI, respectively. The bar chart in Figure 9 shows the wide variations of GAT utilization in the participating aircraft and notations that equipment failures were encountered.

C. GAT Operational Performance - Operational performance demonstrated by the GATs during the test period was determined by correlating qualitative data from the Pilot's Questionnaires, the geographical position and altitude of the aircraft with the transponder's signal quality and radar range as reported by the Air Traffic Control (ATC) facility contacted.

TABLE II

AIRCRAFT FLYING HOURS AND GAT UTILIZATION

Aircraft Type	GAT Type	No. of Flights	Aircraft Flying Hours			GAT Utilization				
						Total Hours	Percent of Flying Hrs.	Percent Usage for		
			IFR	VFR	Total			IFR	VFR	STBY
USAF Douglas VC 47 A	Wilcox	24	60	53	113	92	82	39	48	13
Cessna 180	Wilcox	10	1	10	11	7	64	9	72	19
Gulfstream	Wilcox	3	13	2	15	8	53	50	--	50
Twin Bonanza	Wilcox	32	13	23	36	30	83	30	43	27
USAF Twin Cessna	Hazeltine	51	149	73	222	212	96	60	23	17
Cessna 172	Hazeltine	67	53	68	121	97	80	47	37	16
Beech Bonanza BN-35	Hazeltine	39	29	136	165	103	62	27	72	1
Beech Bonanza K-35	Hazeltine	11	11	4	15	13	87	61	8	31
Beech Bonanza	Hazeltine	37	34	5	39	35	90	94	6	--
All	--	274	363	374	737	597	81	49	37	14
All - Less USAF	--	199	154	248	402	293	72	44	45	11

TABLE III

UTILIZATION OF NORMAL, LOW, AND STANDBY FUNCTIONS OF GAT EQUIPMENT (HOURS)

A. All equipment

		All Conditions		IFR		VFR	
		All	Less USAF	All	Less USAF	All	Less USAF
Position Selector	Number of User Aircraft	9	7	9	7	9	7
Normal	Hours	466	233	269	117	197	116
Low		48	26	22	11	26	15
Standby		83	34	36	14	47	20

B. Wilcox Equipment Only

Position Selector	Number of User Aircraft	4	3	4	3	4	3
Normal	Hours	99	29	44	12	55	17
Low		13	3	6	2	7	1
Standby		25	13	12	7	13	6

C. Hazeltine Equipment Only

Position Selector	Number of User Aircraft	5	4	5	4	5	4
Normal	Hours	367	204	225	105	142	99
Low		35	23	16	9	19	14
Standby		58	21	24	7	34	14

TABLE IV

GAT OPERATIONAL USE AND GAT CONTROL FUNCTION SELECTOR UTILIZATION (PERCENTAGE)

A. All Equipment		All Conditions		IFR		VFR	
		All	Less USAF	All	Less USAF	All	Less USAF
Selector Position	Number of User Aircraft	9	7	9	7	9	7
Norm. & Low	Per-centages	86	89	89	91	82	86
Normal		78	80	82	83	73	76
Low		8	9	7	8	9	10

B. Wilcox Equipment Only

Selector Position	Number of User Aircraft	4	3	4	3	4	3
Norm. & Low		82	71	81	67	83	75
Normal	Per-centages	72	65	71	57	73	71
Low		10	6	10	10	10	4

C. Hazeltine Equipment Only

Selector Position	Number of User Aircraft	5	4	5	4	5	4
Norm. & Low	Per-centages	87	92	91	94	83	89
Normal		80	82	85	87	73	78
Low		7	10	6	7	10	11

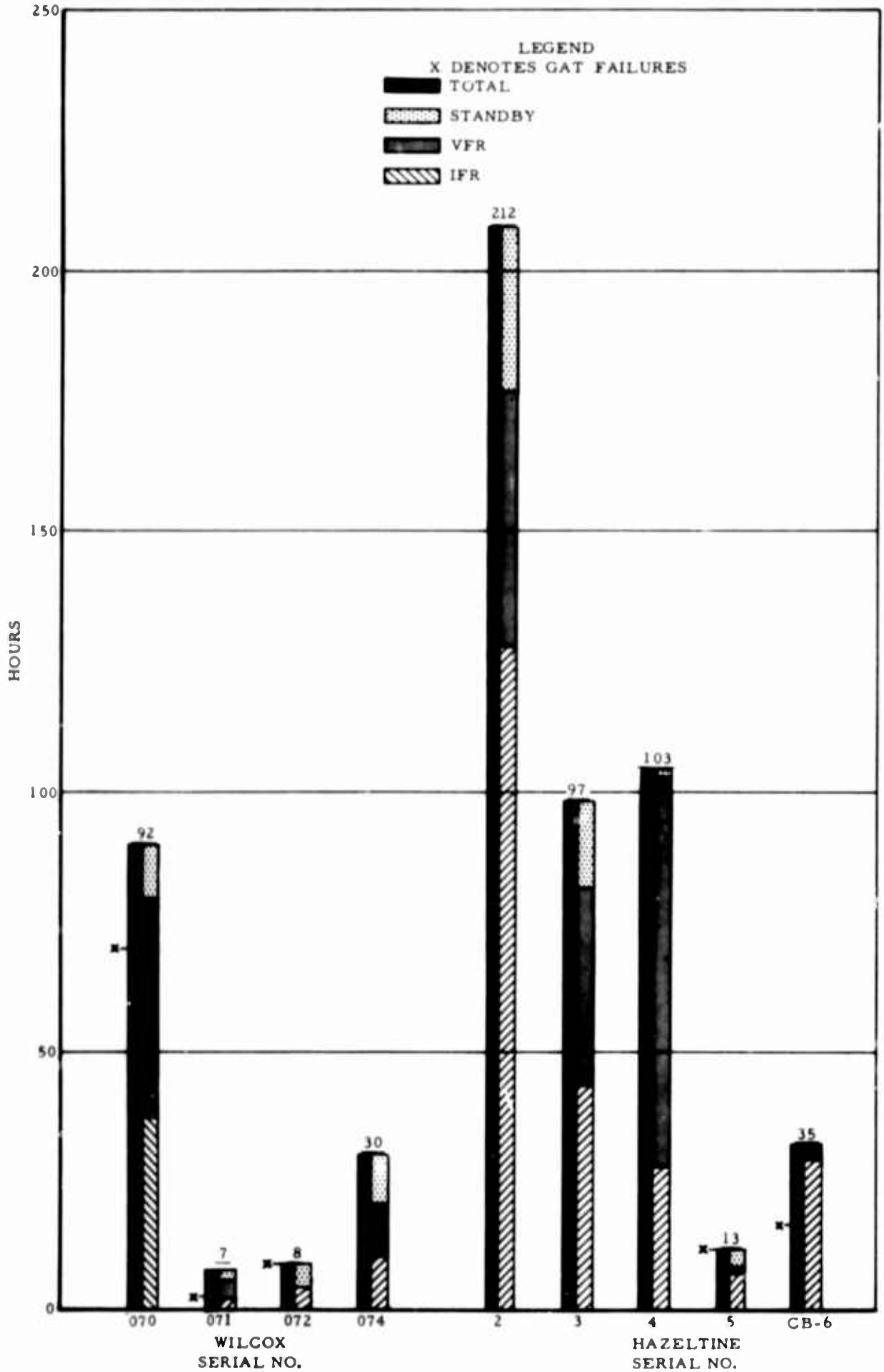

FIG. 9 GAT UTILIZATION (HOURS)

The performance of the GATs in terms of range throughout the test period was shown to be adequate and restricted only by normal radio-line-of-sight conditions. All ATC reports of transponder signal quality, as extracted from 284 Pilot Questionnaires submitted, were in the category of "good," except for six (6) reported instances when the GAT was inoperative. In thirteen (13) instances, signal-quality information was omitted from the report submitted.

D. User-Test Flight Altitudes - The information regarding operating altitudes, as derived from questionnaires submitted by the test participants, is summarized in Table V.

TABLE V

USER TEST FLIGHT ALTITUDES

Total flights reported	274*	
Flights reported 0-4000 feet	36	13%
Flights reported 4000-9000 f et	227	82.5%
Flights reported 9000-11500 feet	11	4.5%

*Some flights were covered by more than one report

E. Reply Code, "Ident" Feature Utilization - The information submitted by the test participants regarding their use of available transponder reply codes has been reduced according to the five codes most frequently used. Table VI presents the results in terms of the percent of operating time during which the several codes were operated in all aircraft, in non-military aircraft, and in military aircraft only.

TABLE VI

CODE SELECTION BY MILITARY AND NON-MILITARY USERS AS PERCENTAGE OF GAT OPERATING HOURS

Transponder Codes	01	06	04	11	10	Others
Military Use, %	67	4	11	4	5	9
Non-Military Use, %	47	20	16	5	3	9
Total Use, %	52	15	15	5	4	9

A more complete analysis of GAT reply code utilization is shown in Table VII. Operation of the "Ident" control was indicated by the test participants in 185 of 284 questionnaires, indicating that this function was utilized during 65 percent of the flights.

TABLE VII

GAT REPLY CODE UTILIZATION

GAT Test Participant Aircraft	GAT Mfr.	No. of Times Code Use Reported																		
		01	02	03	04	06	10	11	12	14	15	16	21	30	50	55	60	67	71	77
USAF Douglas VC 47A	Wilcox	24		4	5	1	4	3		2				1	1					
Cessna 180	Wilcox	5			5	5	1													
Gulfstream	Wilcox	3						5					1							
Twin Bonanza	Wilcox	26			2	12		2			2	2	1							
USAF Twin Cessna U3A	Hazeltine	67		3	10	4	3	2		1										
Cessna 172	Hazeltine	21	4		34	15	7	1	1											1
Twin Bonanza	Hazeltine	26			3	3		1												
Beech Bonanza BN-35	Hazeltine	52		4	12	34	1	3		1	2					1	1		1	
Beech Bonanza K-35	Hazeltine	4	1		3													4		
Beech Bonanza	Hazeltine	39	1		1	5	4	7		7										
TOTAL		267	6	11	75	79	20	24	1	11	4	2	2	1	1	1	1	4	1	1
TOTAL - Less Military		176	6	4	60	74	13	19	1	8	4	2	2	-	-	1	1	4	1	1

Analysis of Pilot's Summary Questionnaire - Twenty-four (15 general aviation and 9 military) of 82 participant pilots submitted Summary Questionnaires (Appendix III) containing information about performance, utilization, maintenance, ATC procedures, and general comments concerning the six-month User Test. Fifty-eight of the 67 military pilots were not requested to submit Summary Questionnaires as their experience with the equipment was limited to a single flight.

The following summarizes the information obtained from the Summary Questionnaires submitted by the 24 pilots of the eight[1] participating aircraft which completed the program. Item 1 of the Questionnaire, which contained personal information about pilots, has not been analyzed for inclusion in this report.

Item 2 - "GAT Usage During the Reporting Period"

Increased	Decreased	No Change	No Comment
11	3	8	2

Item 3A - "GAT Control Box Location"

Convenient position - 20 Awkward position - 4

Item 3B - "GAT Performance"

	Unreliable	Code Switching Difficulties	Pilot Workload Excessive	Operating Range Inadequate
Yes	2	0	1	0
No	21	24	23	23
No Comment	1	0	0	1

Item 3C - "GAT Maintenance and Repairs"

Several equipments were operated without failure. However, Figure 9 shows that five failures were reported during the test period. Four of these failures occurred before the equipment had been operated for 25 hours. Further details are presented below under Maintenance History and in Appendix VII.

---

[1] FAA Gulfstream withdrawn from test participation as a result of GAT environmental temperature problem.

Item 3D - "GAT Installation Information"

No information was supplied.

Item 4 - "ATC Procedure Information"

Readily Available - 14 Satisfactory - 8 Unsatisfactory - 2

Item 5 - "GAT Costs"[2]

1. Considering improved ATC Services made possible by GAT, cost is:

Excessive	Reasonable	Nominal	No Comment
14	8	0	2

2. If GAT cost were reduced by 33 percent, would answers be more favorable?

Yes - 1 No - 0 No Comment - 23

3. If GAT costs were reduced by 50 percent, would answers to above be more favorable?

Yes - 12 No - 4 No Comment - 8

Item 6 - "Pilot Opinion"

In view of the varied influences contributing subjective data to the consensus, for the purpose of analysis the Summary Questionnaires submitted by 24 pilots of GAT-equipped aircraft have been segregated into three (3) categories:

1. General Aviation (G) - Summary Questionnaires were completed by thirteen (13) pilots who operated five of the participating aircraft. Ten (10) questionnaires were completed by pilots of three executive aircraft, and three (3) questionnaires were completed by the pilots of two privately owned aircraft.

---

[2]The cost of the GAT equipments was estimated at approximately $2200.

2. Military (M) - Summary Questionnaires completed by the nine (9) pilots who operated either of the two GAT-equipped military aircraft for more than one flight.

3. AOPA (A) - Summary Questionnaires were submitted by two (2) executive officers who piloted one GAT-equipped aircraft belonging to the Aircraft Owners and Pilots Association (AOPA).

The distribution of responses from these three categories of test participants to each of seven (7) basic statements found in Item 6 of the Summary Questionnaires is summarized in Table VIII. A dispersion was noted in connection with responses to the 4th, 5th, and 7th statements:

Statement #4 - "GAT has no major faults"

	Agree	Undecided	Disagree	No Comment
General Aviation	11	2	--	--
Military	3	5	--	1
AOPA	--	--	2	--

Statement #5 - "GAT is not needed during good weather"

	Agree	Undecided	Disagree	No Comment
General Aviation	1	3	9	--
Military	5	1	3	--
AOPA	2	--	--	--

Statement #7 - "I would voluntarily purchase and utilize a GAT for my next aircraft."

	Agree	Undecided	Disagree	No Comment
General Aviation	9	3	1	--
Military	--	1	3	5
AOPA	--	--	2	--

TABLE VIII
TABULATION OF PILOTS' OPINIONS REGARDING GAT
(ITEM 6 OF USER PILOTS' SUMMARY QUESTIONNAIRE)

STATEMENT ***	Strongly Agree				Agree				Undecided				Disagree				Strongly Disagree				No Comment
	T	G	M	A	T	G	M	A	T	G	M	A	T	G	M	A	T	G	M	A	
1. GAT has been a great help	12	10	2	-	6	3	3	-	3	-	3	-	2	-	1	1	1	-	-	1	--
2. GAT is valuable enough to be used nationwide	12	10	2	-	7	3	4	-	1 1*	- -	1 -	- 1*	2 1**	- -	2 -	- 1**	1	-	-	1	--
3. ATC service received by by pilots using GAT is useful	13	10	3	-	8 1*	3	5	- 1*	1	-	1	-	1**			1**	1	-	-	1	--
4. GAT has no major faults	5	4	1	-	9	7	2	-	7	2	5	-	1	-	-	1	1	-	-	1	1
5. GAT is not needed during good weather	3	-	1	2	5	1	4	-	4	3	1	-	9	6	3	-	3	3	-	-	--
6. Major changes in equip. are needed to make GAT useful	1	-	-	1	1	1	-	-	3	-	3	-	13	9	4	-	3	3	-	-	3
7. I would voluntarily purchase and utilize a GAT for my next aircraft	4	4	-	-	5	5	-	-	4	3	1	-	2	1	1	-	4	-	2	2	5

* IFR ** VFR Both responses from one participant.

*** Total responses (T) for each question, includes answers from General Aviation Pilots (G), Military Pilots (M), and AOPA Pilots (A).

The interpretation of Table VIII could be mistaken unless separate consideration is given to the different interests of the major groups which contributed to the consensus. For example, the majority of the military participants, who had only flown a GAT-equipped aircraft twice, were undecided in their response to Statement #4. The AOPA participants considered that a major fault of the GAT was its cost which, in their opinion, was judged as excessive compared to its operational value.

In response to Statement #5, the majority of military participants and the AOPA representatives were of the opinion that during good weather a GAT is not needed. This was the reverse of the General Aviation response which strongly favored the use of the GAT during good weather.

Statement #7 was not truly applicable to the military pilots as they are generally not aircraft owners. However, AOPA representatives revealed a preference for the purchase of other airborne equipment which would permit direct navigation by the pilot.

For purposes of further examination of the "Agree-Undecided-Disagree" responses to Item 6 of the Summary Questionnaire, a percentile distribution of the opinions of the various test participants is shown in Table IX.

Maintenance History - The investigation of the equipment failures encountered with the GATs during the test period was performed at NAFEC. In general terms, during the Phase III Test Program, five of the nine GATs became inoperative after an average use of less than twenty-five hours. Three of these transponders were manufactured by Wilcox and two by Hazeltine. The three remaining Hazeltine equipments (Serial Nos. 2, 3, and 4) were operated without failures (average use over 135 hours). One Wilcox equipment, Serial #074, was operated for a total of 30 hours and had no reported equipment failure. The general summary of GAT operational history is shown in Table X. A complete description of the transponder-equipment malfunctions, and the repairs accomplished, are contained in Appendix VII of this report.

TABLE IX

PERCENTILE ANALYSIS OF PILOT OPINION REGARDING GAT

STATEMENT	PARTICIPANTS											
	All (24)			General Aviation (13) vs. Military (9)						AOPA (2)		
				A		U		D				
*	A	U	D	G	M	G	M	G	M	A	U	D
1. GAT has been a great help	75	13	12	100	56	--	33	--	11	--	--	100
2. GAT is valuable enough to be used nationwide	76	8	16	100	67	--	11	--	22	--	25	75
3. ATC service received by pilots using GAT is useful	88	4	8	100	89	--	11	--	--	25	--	75
4. GAT has no major faults	61	30	9	85	38	15	62	--	--	--	--	100
5. GAT is not needed during good weather	33	17	50	8	56	23	11	69	33	100	--	--
6. Major changes in equipment are needed to make GAT useful	10	14	76	8	--	--	43	92	57	100	--	--
7. I would voluntarily purchase and utilize a GAT for my next aircraft	47	21	32	69	--	23	25	8	75	--	--	100

* Responses indicated by: A for Agree, U for Undecided, and D for Disagree

TABLE X

SUMMARY OF GAT OPERATIONAL HISTORY

GAT Mfr.	Ser. No.	No. of Failures	Hrs. before Failure	Total Operated Hrs.
Wilcox	070	1	70	92
Wilcox	071	1	2	7
Wilcox	072	4*	5	8
Wilcox	074	None	-	30
Hazeltine	2	None	-	212
Hazeltine	3	None	-	97
Hazeltine	4	None	-	103
Hazeltine	5	1	13	13
Hazeltine	CB-6	1	18	35

*Failures encountered in this Wilcox GAT were the results of high ambient temperatures which existed in the auxiliary radio cabinet of the aircraft (FAA Gulfstream).

Of the four (4) Wilcox Transponders employed in the Phase III Test Program, three (3) equipments failed and required their return to NAFEC for repair. These equipment failures were primarily the result of faulty IF transistors (see Appendix VII). One transponder did not fail, Serial #074, and was reported to have operated for a total of 30 hours.

Of the five (5) Hazeltine Transponders in the Phase III Test Program, two (2) of the equipments failed after 13 and 18 hours of operation respectively (Appendix VII). The other three (3) Hazeltine GATs did not require repair during a total of 412 hours of operation. However, three of the five Hazeltine GATs were not included in the terminal bench tests: one of them was not owned by FAA; another (S/N-3) performed intermittently during bench checks and required a complete overhaul of the pre-selector-converter circuit; the third (S/N-4) was not available for test.

Termination Bench Tests of GAT Equipment - As the GAT equipments were returned by the test participants, the units were subjected to bench test measurements at NAFEC. The "U.S. National Standard for Common System Component Characteristics for the IFF Mark X (SIF), Air Traffic Control Radar Beacon Systems SIF/ATCRBS" contains the criteria for testing the performance characteristics with respect to the overall requirements of the Common System. These tests revealed that degradation of performance had occurred in all GAT equipments. In each instance, the degradation was an "out-of-tolerance" condition for one or more specific tests. Results are summarized in Table XI and described in greater detail within Appendix VIII of this report. A pattern of transponder performance deterioration was noted as follows:

A. Wilcox Transponders - Four tested:

1. Sensitivity - Faulty IF transistors reduced the sensitivity in all four equipments.

2. Transmitter Frequency - Two equipments were off-frequency.

3. External Suppression Pulse Output - Pulse slightly wider than 30 μsec on three equipments.

The first two conditions would seriously affect the performance capability of the GAT. The third would have virtually no effect on either the GAT or on other equipments which would be using this suppression pulse.

B. Hazeltine Transponders - Two tested:

1. Side Lobe Suppression - Both equipments--inadequate suppression action at -30, -25, and -20 dbm interrogation levels at reply rates of 90 percent and 10 percent.

2. Transponder Delay Time - Both equipments--at interrogation levels of -40, -50, -60, and -74 dbm, the transponder delay-time limit was exceeded.

The first condition would affect the GAT's ability to be used near the ground site. The second condition was marginal and would not seriously have affected the operation of the GAT.

TABLE XI

SUMMARY OF SIF/ATCRBS COMMON SYSTEM STANDARDS NOT MET FOLLOWING SIX-MONTH GAT USER TEST

Test Parameters	Wilcox				Hazeltine	
	Serial Numbers					
	070	071	072	074	2	5
Reply Pulse, Ident						X
Minimum Trigger Level	X	X	X	X	X	X
Receiver Bandwidth	X				X	*
Sensitivity Reduction Reply Limit Control		X	X			X
SLS Rate-Limiter Sensitivity Reduction		X	X			
Decoding Accuracy and Discrimination	X	X	X			
Side Lobe Suppression					X	X
External Suppression-Pulse Output	X		X	X		X
Control-Pulse Spacing						X
Reply Pulse Characteristics, Pulse Spacing				X		X
Transmitter Frequency		X	X			
Power Output, Pulse Width						X
Transponder Delay Time					X	X

* Not tested

Deficiencies were measured in 31 specific instances of which 18 were found in four Wilcox equipments and 13 were found in two Hazeltine equipments.

There are two facts which are entitled to consideration during any interpretation of the post-flight bench tests of the GATs; these are: (a) all but one of the transponders had been bench-tested before the start of Phase III, User Tests, and were known to be performing within correct tolerances; (b) no reports of GAT malfunction originated as a result of observations of the ATCRBS ground facilities. This is due to the fact that most of the malfunctions were either so trivial that their effect on the systen was negligible or the nature of the malfunction was such that it could not be discerned by simply observing the display. In general, SLS malfunctions could not be determined because the necessary ground equipment for SLS has not been installed. Actual failures which occurred in six cases during flight were discovered when pilots requested ATC identification.

SUMMARY OF RESULTS

1. The results derived from the Pilot's Questionnaire submitted during User Tests, Phase III evaluation of the General Aviation Transponders, are summarized as follows:

a. Transponders were operated 597 hours during 737 reported aircraft flying hours; thus, utilization was 81 percent. Two hundred twenty-three (223) hours were under VFR flight conditions, 291 hours were under IFR flight conditions, and 83 hours were in standby.

b. The altitudes flown during 274 reported flights were distributed as follows: 13 percent at 4000 feet and below, 82 percent between 4000-9000 feet, and 5 percent between 9000-11,500 feet.

c. The more frequently used reply codes were as follows: "01" (52 percent); "06" (15 percent); "04" (15 percent); "11" (5 percent); "10" (4 percent); all other codes (9 percent).

d. The "Ident Feature" was used during 65 percent of the reported flights.

e. The equipment range was considered adequate by the participant pilots.

f. The quality of the displayed response from the transponders, as reported by ATC personnel to the pilots, was considered "good" in all but six instances; the GATs involved in these instances were later found to have been inoperative.

2. Results in the form of general opinions were drawn from the Pilot's Summary Questionnaire, as submitted by 24 participants; these are grouped below as Strong Responses representing the opinions of a large majority and Marginal Responses representing the opinions of a small majority.

a. <u>Strong Responses</u>

(1) The equipment has been helpful.

(2) The GAT Control Head was in a convenient position.

(3) There was no difficulty in code switching.

(4) Pilot operation of the GAT did not create excessive workload.

(5) Range was adequate.

(6) Performance of the transponder was considered reliable.

(7) ATC service received by pilots using GAT was considered useful.

(8) The equipment was considered valuable enough to be used nationwide.

(9) The cost of this type of transponder was judged to be excessive.

b. Marginal Responses

(1) GAT has no major faults.

(2) GAT would be voluntarily purchased with the participant's next aircraft acquisition and the equipment would be utilized.

3. Five of the nine participating aircraft returned to NAFEC for transponder repair.

a. IF transistor failures occurred in three of the GATs.

b. Five of the GATs failed in less than 22 hours of operation.

4. Termination Bench Tests of the six available GATs indicated that:

a. None of these transponders satisfied all the test requirements cited in Specification SIF/ATCRBS, Common System Standard.

b. Eighteen deficiencies were distributed among the four Wilcox transponders.

c. Thirteen deficiencies were found in two Hazeltine transponders, one transponder requiring major repair.

5. The most notable limitations of transponder performance were generally as follows:

a. Wilcox GAT - Sensitivity, Transmitter Frequency, and External Suppression Pulse Output.

b. Hazeltine GAT - Side-Lobe-Suppression and Transponder Delay Time.

CONCLUSIONS

Based upon the results of the evaluation of the Wilcox and Hazeltine General Aviation Transponders (GAT) conducted under Project No. 108-030-01V, it is concluded that:

1. While both types of General Aviation Transponders (Wilcox and Hazeltine) met the contract performance specifications during laboratory and flight tests, design changes are required due to malfunctions and deterioration of certain performance levels that occured during a relatively short period of operation in typical user aircraft. Measurements made after both types of equipment had been operated in flight, demonstrated that the performance of the GATs tended to deteriorate toward unacceptable levels.

2. Acceptance and utilization of the GAT by the General Aviation Community depend upon the extent to which its purchase price can be reduced and the equipment operational life increased. The potential user-benefits of GAT, such as reduced communications and expediting traffic, are somewhat overshadowed by the present purchase price of the equipment.

RECOMMENDATIONS

Based on the results of the evaluation of the Wilcox and Hazeltine General Aviation Transponders (GAT), it is recommended that:

1. The FAA continue to foster the introduction of transponders to General Aviation by a program which includes the following:

   a. Present a clear understanding of the manner in which the ATCRBS can provide for identification, reduced delays, and minimum communication workload.

   b. Conduct further investigations of design changes toward extending the operational life of the equipment and reducing the unit cost.

   c. Expedite the development of airport test facilities for the pilot's pre-flight check of the transponder.

2. Any further procurement of GAT, or like equipments which are designed to operate with the ATCRBS, be made contingent upon thorough factory test in a calibrated facility where performance, accuracy, stability, and improved operational life of the equipment can be demonstrated by its manufacturer.

3. The FAA encourage the General Aviation Community to make use of the service available through GAT equipment until such time as the Small Light-Weight Altitude Equipment (SLATE) becomes commercially available and the planned companion improvements to the ATCRBS can be implemented, provided the manufacturers of GAT can demonstrate appropriate stability and reliability in their production models.

REFERENCES

1. Wilcox Electric Company Inc., Final Engineering Report, Design and Development of the General Aviation Transponder, Contract FAA/BRD-234.

2. Wilcox Electric Company, Inc., Instruction Manual for General Aviation Transponder Model 814, Instruction Manual No. 304467-300.

3. Hazeltine Corporation, Final Engineering Report on General Aviation Transponder, Contract No. FAA/BRD-233.

4. Hazeltine Technical Development Center, Inc., Handbook of Operating and Maintenance Instructions for General Aviation Transponder, IB No. 2007.

5. U.S. National Standard for Common System Component Characteristics for the IFF Mark X (SIF), Air Traffic Control Radar Beacon System, SIF/ATCRBS, dated 12/27/63.

ACKNOWLEDGMENT

Acknowledgment is made of the services rendered by Messrs. Oscar Adams and James Norton of Experimentation Division, Electronics Branch, who performed screen room tests on GAT equipment and by Mr. B. Solomon of Technical Services Division, Flight Operations Branch, who coordinated the GAT installation in the User Test aircraft.

APPENDIX I

AIRCRAFT WHICH PARTICIPATED IN GAT USER TEST PROGRAM

Aircraft	Organization	Reg. No.	GAT Type Installed	Serial No.
Douglas VC 47A	USAF, Andrews Air Force Base, Washington, D. C.	0-15980	Wilcox	070
Cessna 180	AOPA, Bethesda, Md.	N-2857A	Wilcox	071
Grumman Gulfstream	FAA, Hangar No. 6, Washington National Airport	N-1	Wilcox	072
Beech Twin Bonanza	Sprague Electric Co., (NBAA) N. Adams, Mass.	N-17S	Wilcox	074
Twin Cessna U3A	USAF, Andrews Air Force Base, Washington, D. C.	A-82116	Hazeltine	2
Cessna 172	Cotton & Cappozzli, (Co-owners) East Palo Alto, California	N-6470E	Hazeltine	3
Beech Bonanza BN-35	Maj. Gen. J. B. Bestic, Pentagon, Wash., D. C.	N-5092C	Hazeltine	4
Beech Bonanza K-35	Matrix Corp., Wash., D. C.	N-5315E	Hazeltine	5
Beech Bonanza	Barber-Colman Co. Rockford, Ill.	N-41F	Hazeltine	CB-6

APPENDIX II

GENERAL AVIATION TRANSPONDER (GAT)
Pilot's Questionnaire

Federal Aviation Agency GENERAL AVIATION TRANSPONDER (GAT) Pilot's Questionnaire		PROJECT 108-8V TEST DATA FORM (TEMP) #1 EXPIRES 9/1/63
1. Pilot's Name (Last, first, middle initial)	2. Address (No., St., City, and State)	3. Telephone No. (Area Code and No.)

4. Aircraft Registration No.	5. Date of Flight	6. Type of Flight Rules ☐ IFR ☐ VFR ☐ DVFR ☐ IFR-VFR ☐ VFR-IFR ☐ FVFR

7. Flight Plan Date	Route of Flight		

8. GAT FLIGHT REPORT

Number of IFR Hours (nearest quarter) flown this flight _____ Hours
Number of VFR Hours (nearest quarter) flown this flight _____ Hours
Number of hours GAT used this flight in:

	IFR		VFR	
A. Normal	(_____	Hrs.	(_____	Hrs.
B. Low	(_____	Hrs.	(_____	Hrs.
C. Standby	(_____	Hrs.	(_____	Hrs.

Maximum reported range by an ATC Facility on GAT Response this flight _____ miles
ATC Facility making report (ie: CHI ARTCC or ORD Apr. Cont.) _____
Your location at time of report by ATC (ie: Over Joliet Radio or 45 mi. SW ORD on VOR 220° radial). _____
Your altitude at time of this report by ATC _____ ft. (MSL).
Your GAT code setting at time of report. Code # _____
GAT signal quality as reported by ATC Good _____ Fair _____ Poor _____
Was use of SPI "Ident" feature requested by ATC during flight Yes ____ No _____
If Yes, approximate number of times under IFR _____ VFR _____

9. Any indication of GAT malfunctioning ☐ No ☐ Yes (Explain below)

10. Comments or suggestions

Signature

PROJECT 108-8V FORM #1 (TEMP)

INFORMATION SHEET

(For insertion and inclusion in Pilot's Questionnaire)

GAT USER TEST

To foster use of airborne transponder equipment associated with ground radar beacon equipments for use in FAA Air Traffic Control System, System Research and Development Service has arranged to conduct a "User Test" under actual operational conditions. The tests will begin on or about January 1, 1963, and end on or about June 30, 1963.

The Agency would appreciate a full report of your experience with GAT and any comments and suggestions which you may like to submit. Two questionnaires have been developed for this purpose. One is a Pilot's Questionnaire, which is to be completed for each flight, the other is a Pilot's Summary Questionnaire, which will be mailed to all participating pilots for completion on a bi-monthly basis.

GENERAL INSTRUCTIONS AND INFORMATION

The Pilot's Questionnaire (this form) is to be completed after each flight.

Item 6 - Type of Flight Rules, "IFR-VFR" implies that you start your flight IFR and continue VFR or vice versa, as indicated.

Item 7 - Flight Plan Data, Route of Flight - use appropriate abbreviated designators as listed in Airman's Guide (i.e., PIT Dep. Cont. via V37, MGW, V144, ESL, LDN, DCA App. Cont.).

Item 8 - GAT Flight Report - for your location at time of maximum range contact by ATC, suggest the following format: V144, 15 mile SE ESL 8000', etc.

Item 10 - Comments or suggestions - to include advantage, if any, of "Ident" feature, your experience in reduction of radio, communications, the elimination of identification turns, etc.

If you have any comments, suggestions, or require additional quantities or information on the questionnaires, call the Project Manager's Office, collect on any weekday between 10:00 a.m. and 2:00 p.m., EST for assistance. Identify your call with your name and "GAT USER". Telephone: Pleasantville, New Jersey, Area Code 609, 641-8200, Extension 2546 (or 2320).

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APPENDIX III

GENERAL AVIATION TRANSPONDER (GAT)
Pilot's Summary Questionnaire

Federal Aviation Agency GENERAL AVIATION TRANSPONDER (GAT) PILOT'S SUMMARY QUESTIONNAIRE	PROJECT 108-8V TEST DATA FORM (TEMP)#2 EXPIRES 9/1/63
Name and Address of Pilot	Pilot's Telephone Number Area Code / Number
	1. IDENTIFICATION
	Aircraft Registration No.
	GAT Manufacturer's Name
	Date GAT Installed

2. GAT USAGE During Reporting Period (Check One)		Increased	Reason for Change in Usage
		Decreased	
		Remained the Same	

3. GAT A. Control Box Location (Answer on initial report or if location is changed.	A. LOCATION			
		In Convenient Position		Comments
		In Awkward Position		
	B. PERFORMANCE - GAT USE			
B. GAT Performance			Yes	No
		Was Unreliable		
		Was Difficult Due to Code Switching		
		Created Excessive Pilot Workload		
		Was Handicapped by Inadequate Range		
	C. MAINTENANCE AND REPAIRS			
C. GAT Maintenance and Repairs			Yes	No
	Required Type (Number of Times)		Major	Minor
				(Explain nature of maintenance required, time out of service, names, location of servicing activity.)
D. GAT Installation Information	Other electrical modifications to aircraft in addition to GAT installation (such as main power bus rewiring, higher capacity generator.)			
	If yes, Explain		Yes	No
				(Information required on initial report submitted or to note subsequent changes to aircraft.)

4. ATC Procedures Information		Readily Available	Comments
		Satisfactory	
		Unsatisfactory	

PROJECT 108-8V FORM #2 (TEMP)

A. Considering the improved ATC services made possible by the GAT, I feel the cost is:	Excessive	Reasonable	Nominal	

B. If the GAT cost could be reduced by 33% ___ 50% ___ (check one) would your answer to above be more a favorable Yes ___ No ___

6. PILOT'S OPINION	Indicate how strongly you agree or disagree with each statement by placing an "X" in the appropriate column.	Strongly Agree	Agree	Un-decided	Dis-Agree	Strongly Disagree
	GAT has been a great help					
	GAT is valuable enough to be used nationwide					
	ATC service received by pilots using GAT is useful					
	GAT has no major faults					
	GAT is not needed during good weather					
	Major changes in equipment are needed to make GAT useful					
	I would voluntarily purchase and utilize a GAT for my next aircraft					

ADDITIONAL COMMENTS (If necessary to qualify or explain any answers identify by item number. Attach additional sheets, if necessary.)

7. Any other comments that you feel are appropriate for consideration and evaluation of the GAT.

Date	Signature

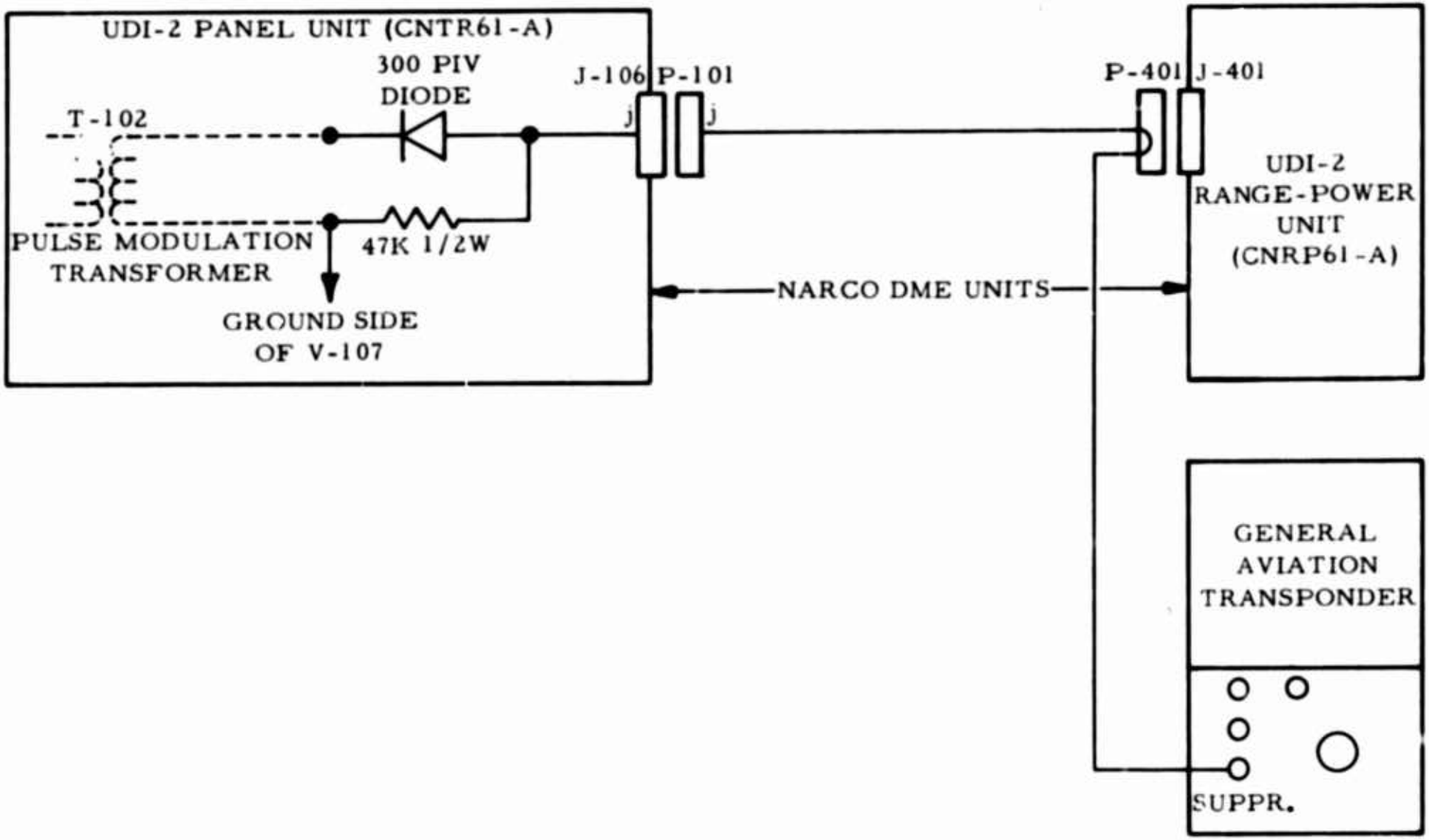
Return To:

FEDERAL AVIATION AGENCY
NATIONAL AVIATION FACILITIES
EXPERIMENTAL CENTER
ATTENTION: RD-5051
ATLANTIC CITY, NEW JERSEY

For additional information, call the Project Manager's Office collect any weekday between 10 a.m., and 2 p.m., e.s.t., for assistance. Identify your call with your name and "GAT USER." Telephone: Pleasantville, New Jersey, Area Code: 609 641-8200 Ext. 2546 (or 2320)

APPENDIX IV

NARCO DME SUPPRESSION MODIFICATION



APPENDIX V
GAT UTILIZATION, HOURS OF OPERATION

WILCOX GAT EQUIPPED AIRCRAFT

Aircraft	GAT Serial No.	IFR and VFR GAT Selector Position			IFR GAT Selector Position			VFR GAT Selector Position		
		Normal	Low	Standby	Normal	Low	Standby	Normal	Low	Standby
Douglas VC 47A	070	70	10	12	32	4	5	38	6	7
Cessna 180	071	6	-	1	1	-	-	5	-	1
Gulfstream	072	4	-	4	4	-	3	-	-	1
Twin Bonanza BN-50	074	19	3	8	7	2	4	12	1	4

HAZELTINE GAT EQUIPPED AIRCRAFT

Twin Cessna U3A	2	163	12	37	120	7	17	43	5	20
Cessna 172	3	63	18	16	38	8	4	26	10	12
Beech Bonanza BN-35	4	98	4	1	27	-	-	70	4	1
Beech Bonanza K-35	5	9	-	4	8	-	3	1	-	1
Beech Bonanza	CB-6	34	1	-	32	1	-	2	-	-

APPENDIX VI

GAT UTILIZATION, PERCENTAGE OF FLIGHT HOURS

WILCOX GAT EQUIPPED AIRCRAFT

Aircraft	GAT Serial No.	IFR and VFR GAT Selector Position			IFR GAT Selector Position			VFR GAT Selector Position		
		Nor & Low	Nor	Low	Nor & Low	Nor	Low	Nor & Low	Nor	Low
Douglas VC 47A	070	87	76	11	88	79	9	86	74	12
Cessna 180	071	86	86	-	100	100	-	83	83	-
Gulfstream	072	50	50	-	57	57	-	-	-	-
Twin Bonanza BN-50	074	75	65	10		54	16	77	71	6

HAZELTINE GAT EQUIPPED AIRCRAFT

Twin Cessna U3A	2	82	77	5	88	83	5	70	63	7
Cessna 172	3	84	65	19	91	76	15	76	55	21
Beech Bonanza BN-35	4	99	95	4	100	100	-	99	93	6
Beech Bonanza K-35	5	69	69	-	73	73	-	50	50	-
Beech Bonanza	CB-6	100	97	3	100	97	3	100	100	-

APPENDIX VII

MAINTENANCE SUMMARY OF WILCOX AND HAZELTINE GATS

GAT Type; Serial No.	Aircraft Type	Failure Date	Difficulty	Remarks
Wilcox S/N 070	Douglas VC-47A	3/4/63	Failure of unit-digit section of code-selector control.	Removed control head, aligned code-digit wheel and secured knob to digit-code shaft.
		6/3/63	Transmitter Tube V1 (GL-6442) grid control lead intermittently shorting to cavity shell (chassis ground)	Repositioned and secured Mylar insulators of tube cavity to prevent grid-to-ground short circuiting.
			Low MTL sensitivity (-70 dbm)	Replaced faulty 1st IF transistor. Q3 (PADT-28) with production-replacement Type 2N2494, to restore MTL sensitivity to the required level of -74 dbm.
			Low peak-power output	Pulse-width control (R-176): adjusted from 55.8 to 56.5 dbm
Wilcox S/N 071	Cessna 180	3/8/63	Low MTL Sensitivity (-35 dbm)	Replaced 5th IF transistor Q7, (PADT-28) with production-replacement Type 2N2494, to restore MTL to -74 dbm.

MAINTENANCE SUMMARY OF WILCOX AND HAZELTINE GATS

GAT Type; Serial No.	Aircraft Type	Failure Date	Difficulty	Remarks
Wilcox S/N 072	Gulfstream	9/11/62 (Earlier failure dates not reported)	Low MTL Sensitivity	Replaced 4th IF transistor Q6, (Type PADT-28) to restore MTL sensitivity to -74 dbm
		2/10/63	Low MTL Sensitivity	Same as above
		1/13/63) 2/10/63) 2/12/63)	Intermittent operation - cause determined to be excessive ambient temperature	Heavy commitments of this aircraft to other work precluded correction of temperature environment for the GAT; this aircraft was withdrawn from the test program along with its GAT in Feb., 1963
Wilcox S/N 074	Twin Bonanza BN-50	--	None	None required
Hazeltine S/N 2	Twin Bonanza USAF U3A	2/8/63	Defective "LO-NRML-STDBY-OFF" selector knob on GAT control box.	New control knob was installed and realigned after which equipment operated normally for 212 hours until the end of the test program

MAINTENANCE SUMMARY OF WILCOX AND HAZELTINE GATS

GAT Type; Serial No.	Aircraft Type	Failure Date	Difficulty	Remarks
Hazeltine S/N 3	Cessna 172	--	None	None required
Hazeltine S/N 4	Beech Bonanza BN-35	--	None	None required
Hazeltine S/N 5	Beech Bonanza K-35	6/13/63	Intermittent operation. Grid-contact ring of the cavity in transmitter tube, (Type 2C39) made contact with chassis ground; this short circuit resulted in damage to thermal delay relay (K-5002) and transmitter-tube bias potentiometer (R-4008).	Nature and extent of damage to the GAT, as a result of intermittent short circuiting, prevented repair: equipment withdrawn from test program
Hazeltine S/N CB-6	Beech Bonanza	3/29/63	Intermittent operation. A faulty oscillator tube, V1001, (Type 7793) together with the associated printed circuit board found defective.	Equipment shipped to the manufacturer's plant in Indianapolis, Ind., for repairs. After defective parts were replaced, equipment was reinstalled in the aircraft; it operated successfully for the remainder of

APPENDIX VIII

DETAILED TERMINATION BENCH TEST RESULTS
TEST PARAMETERS AFFECTED

Item Number		Wilcox				Hazeltine	
Appendix		GAT Serial Number					
II *	III *	070	071	072	074	2	5
4	(4)						f
6	(6)	a	b	c	d	e	f
9	(10)	a				e	f
11	(12)		b	c			f
15	- -		b	c			
16	(13)	a	b	c			
12	(16)					e	f
18	(14)	a		c	d		f
14	(18)						f
20	(20)				d		f
22	(22)		b	c			
23	(23)						f
26	(26)					e	f

* Refers to the Interim GAT Report and the tests outlined in Appendix II (Wilcox) and Appendix III (Hazeltine)

REMARKS

(4) REPLY PULSES

f. Ident pulse inoperative - open Ident-Pulse-Amplifier transistor (Q3303) was replaced.

6/(6) MINIMUM TRIGGER LEVEL

a. Normal Receiver Sensitivity 2 db down from -74 dbm reference. This was after 22 hrs. of GAT use when equipment had first repair[1] on 6/3/63.

b. Normal sensitivity OK after only 5 hrs. operation by user. [2]

c. First IF transistor (Q3) replaced. Sensitivity changed from -43 to -74 dbm.[3]

d. Normal sensitivity increased from -70 to -74 dbm after changing Local Osc. (Q1) and Amplifier (Q2) and 6th and 8th IF transistors (Q8 & Q10). Total GAT use 30 hrs.

e. Readjusted from -72.5 to -74 dbm after 212 hours of operation.

f. Readjusted from -71 to -74 dbm. Returned for repair after 13 hours of operation.

9/(10) RECEIVER BANDWIDTH

a. Receiver bandwidth, at 60 db above MTL highside, exceeded upper frequency limit by over 7 megacycles (1062.16, limit 1055 megacycles).

e. Center frequency 1031.669 megacycles. All 3 db, 40 db, and 60 db low and high side bandwidth measurements above MTL exceeded tolerance.

f. Not checked.

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[1] At this time, normal sensitivity was corrected to -73 dbm after being 4 dbm down following an initial 70 hrs. of operation.

[2] Unit in for repair initially after 2 hrs. of operation. Fifth IF transistor replaced which changed sensitivity from -35 to -74 dbm.

[3] GAT formerly in for repair 9/10/62, 1/10/63, as well as other times earlier. Fourth IF transistor (Q6) replaced each time. Diagnosis was lack of ventilation in the aircraft installation which caused elevated temperatures and resultant transistor failures. Total GAT use 8 hrs.

11/(12) SENSITIVITY REDUCTION REPLY LIMIT CONTROL

Automatic overload control required adjustment to prevent sensitivity reduction in excess of 3 db to take effect after 90 percent of pulse repetition rate of 1200 Interrogations Per Second (IPS), - recommended value.

b. Automatic Overload Control (R-133), was adjusted from -59.2 dbm to -62 dbm at 1200 IPS (reference 1000 IPS at -65 dbm).

c. IPS level of -62 dbm corresponded to an interrogation rate of 933 IPS. This was set to 1200 IPS and the Automatic Overload Control (R-133) was readjusted.

f.. IPS level of -62 dbm corresponded to an interrogation rate of 1079 IPS. This was set to 1200 IPS and the Automatic Overload Control (R-3401) was readjusted.

15. SLS RATE LIMITER SENSITIVITY REDUCTION

b. Interrogation level at 1200 IPS, -10.5 db above reference (limit 3 db above -65 dbm reference).

c. INT/SEC at 30 db above initial reference is 1528 (limit 1500).

16. DECODING ACCURACY AND DISCRIMINATION

a. Mode A long side at 90% replies 9.04 u sec. (<9.0 u sec.)
Mode A long side at 10% replies 9.08 u sec. (<9.0 u sec.)

b. Mode A short side at 10% replies 6.95 u sec. (>7.0 u sec.)
Mode A long side at 10% replies 9.01 u sec. (<9.0 u sec.)

c. Mode A short side at 90% replies 6.90 u sec. (>7.0 u sec.)
Mode A short side at 10% replies 6.84 u sec. (>7.0 u sec.)
Mode A long side at 90% replies 9.0 u sec. (<9.0 u sec.)
Mode A long side at 10% replies 9.1 u sec. (<9.0 u sec.)

(16) SIDELOBE SUPPRESSION

e. & f. Insufficient suppression action at -30, -25, and -20 dbm interrogation levels at 90 and 10% reply rates.

18/(14) EXTERNAL SUPPRESSION PULSE OUTPUT

a. 300 and 2000 ohm termination - external suppression pulse out duration 31.5 u sec. (limits, 25 - 30 u sec.)

c. 32.0 u sec.

d. 30.7 u sec. with 1.6 u sec. jitter in trailing edge.

f. Pulse amplitude 18 volts, limits 20 to 70 volts.

(18) CONTROL PULSE SPACING

f. SLS failed to optimize at 2.0 u sec. (peak at 2.8 u sec.).

20/(20) REPLY PULSE CHARACTERISTICS

d. Pulse spacing, first to ident, 24.76 u sec. (limit, 24.65 $\pm$ 0.1 u sec.)

f. Pulse spacing, first to ident, 24.79 u sec.

22. TRANSMITTER FREQUENCY

b. 1084.79 megacycles, limit 1090 $\pm$ 3.0 megacycles.

c. 1113.59 megacycles.

(23) TRANSMITTER POWER OUTPUT (00 code)

f. 1st and 2nd pulse width 0.56 u sec. (limit 0.45 $\pm$ u sec.).

(26) TRANSPONDER DELAY TIME

e. and f. At interrogation signal levels of -40, -50, -60, and -74 dbm transponder delay time limit (3 $\pm$ 0.5 u sec.) was exceeded.